agricultural research

U.S. DEPARTMENT OF AGRICULTURE DECEMBER 1975

agricultural research

December 1975/Vol. 24, No. 6

Tomorrow's Bounty

Experts disagree about whether the humid tropics—a generally impoverished region of seemingly lush abundance—can be exploited to help feed the world's burgeoning population.

Some observers all but dismiss most of this region as potential farm land. They contend that the nutrients are limited and concentrated in the vegetation. This low level of fertility is maintained by a rapid and efficient recycling of mineral nutrients between plants and soil under a dense canopy of foliage that shields the soil from driving rain and searing sun. Expose the soil to open cultivation, these experts say, and it is doomed. The heavy rains and heat soon leach nutrients and oxidize organic matter.

Other observers are optimistic. They argue that the tropics, like the temperate regions, are too varied for broad generalizations. For example, even with little organic matter, record crop yields have been obtained with proper fertilization, water control, and soil management. And while most soils in the humid tropics are infertile, modern agriculture rarely relies upon natural fertility.

Indeed, present agricultural technology and management can make sizeable portions of the humid tropics arable. In the Philippines, for example, scientists have grown as many as five crops in a year. And the intensive management systems developed by ARS scientists in Puerto Rico to produce more forage, milk, plantains, and sugarcane, for example, provide further evidence of what today's technology can achieve.

But a concerted effort must get underway before the tropics can grow food in abundance. This effort would benefit from a thorough review of research on tropical agriculture conducted over several decades by former colonial powers; much of this published research has gone unread. Then more regional research centers—there are only a few—need to be established in ecological zones. Since vast areas of the tropics have similar soils and climates, research findings could be widely adapted. A high priority research need is the breeding of locally adapted crops that respond to chemical fertilizers.

Science can help harness the resources of the humid tropics, a region of favorable rainfall, sunlight, and temperature and where plants grow without respite the year around. Despite substantial problems, these natural advantages are too important to ignore in the race between the stork and the plow.—*R.P.K.*

Editor: *R. P. Kaniuka*

Contributors to this issue:

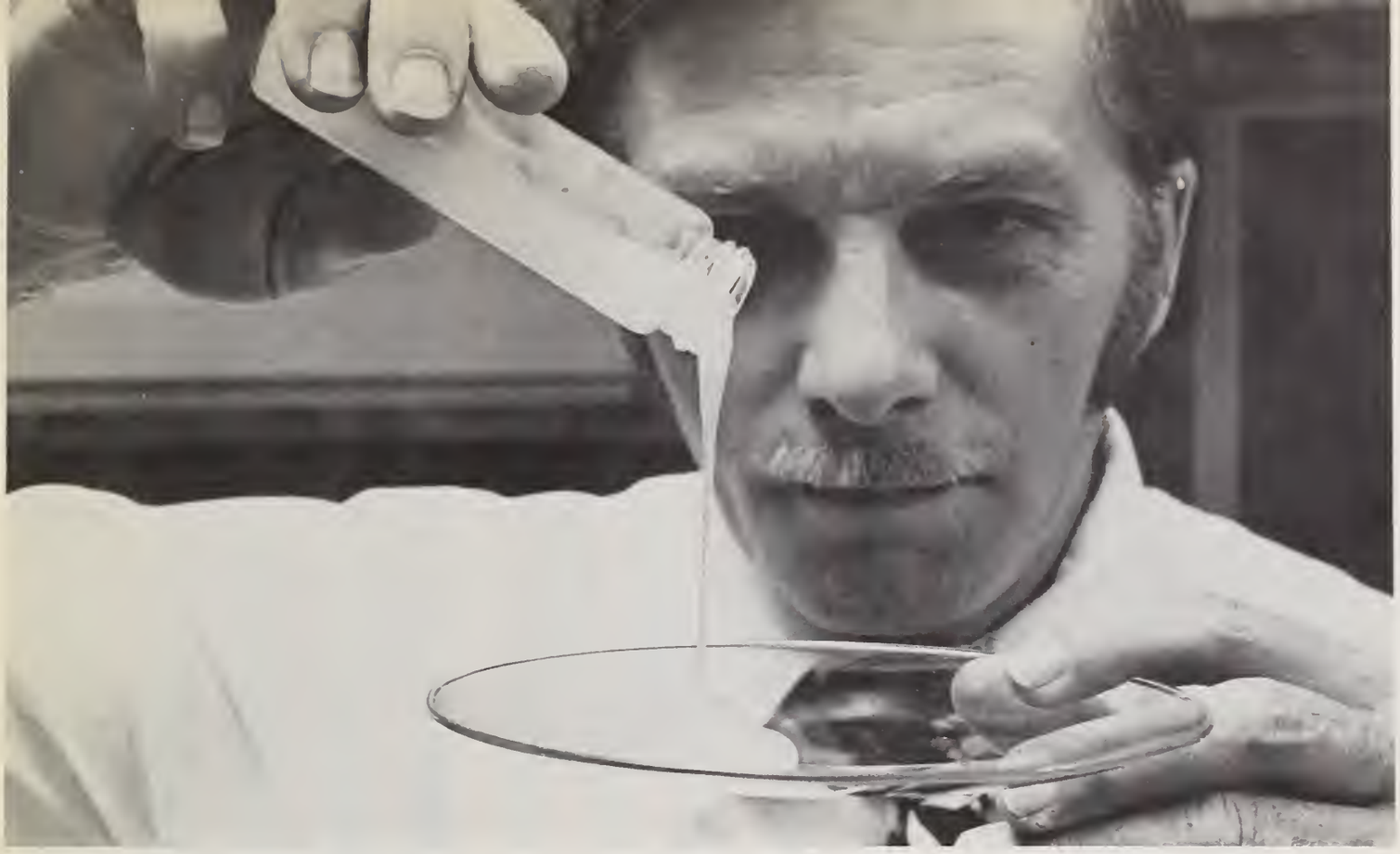
R. C. Bjork, F. W. Faurot, P. L. Goodin, M. C. Guilford, G. B. Hardin, D. H. Mayberry, W. W. Martin, J. L. Sanders, D. H. Senft, L. C. Yarris

COVER: The cabbage looper larva—*Trichoplusia ni*—eats its way through a soybean leaf. Much of the research at the Biological Control of Insects Research Unit is aimed at controlling this and other pests of soybeans (0975X1786–23A). Article begins on page 8.

AGRICULTURAL RESEARCH is published monthly by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 15, 1977. Yearly subscription rate is $5.05 in the United States and countries of the Postal Union, $6.35 elsewhere. Single copies are 45 cents. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by photo number.

Earl L. Butz, Secretary
U. S. Department of Agriculture

Talcott W. Edminster, Administrator
Agricultural Research Service



It takes only 1 part of the food gum—xanthan—in 100 parts of water to provide a viscous or "thick" solution. Xanthan gum, developed in earlier Northern Laboratory research and used commercially in foods such as salad dressings, can now serve in making high-protein batter foods (0975R1883–33).

for strength and elasticity

NEW, high-protein, baked foods made by cereal chemists from corn or wheat starch and soybean protein depend upon a food gum that functions as a foam-forming binder—as gluten functions in bread.

Xanthan gum gives starch doughs and batters the strength and elasticity to rise by forming foam cells and expanding with air and carbon dioxide generated by yeast or leavening agents such as baking powder or soda.

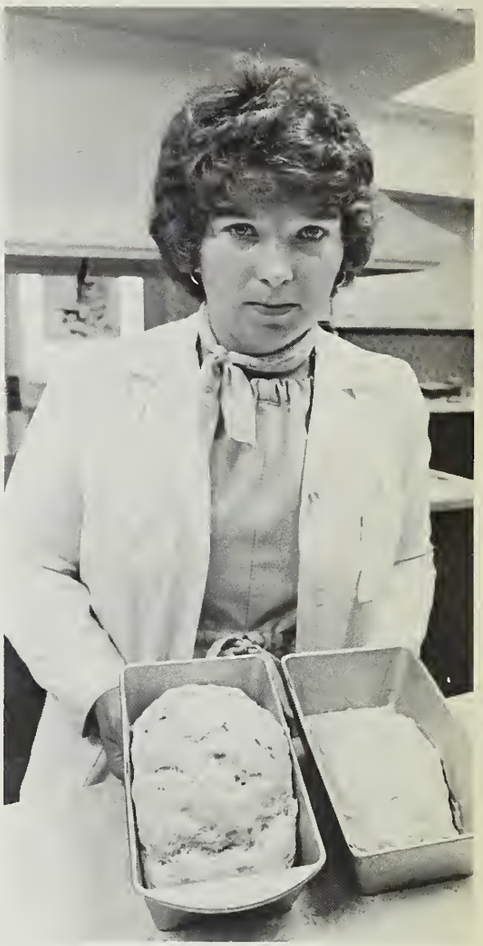
Studies of non-gluten and low-gluten doughs and batters by chemists Donald D. Christianson and Harold W. Gardner, of the Northern Regional Research Center, indicate that xanthan gum and starch form a foamed matrix that hardens when baked. In subsequent flavor studies by home economists Kathleen A. Warner and Brenda K. Boundy, taste panel members did not detect soy flavor in any of the foods tested at the 15 percent level of soy-protein addition.

The studies demonstrate that xanthan gum is compatible with oilseed proteins and can give flexibility in formulating doughs and batters to meet a range of individual to international food needs.

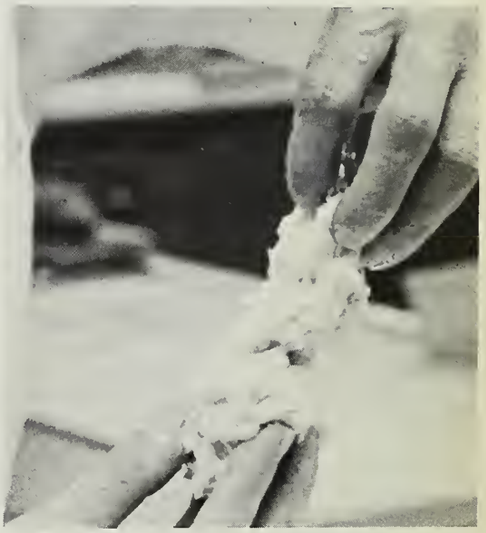
For example, the gum might be used in baked foods for persons allergic to gluten, or to meet growing demand for baked foods in world areas where bread wheats are not grown. It might be used to make doughs and batters from all kinds of starch or from nonbread wheat flours.

Xanthan gum might also be used in new foods made nutritionally complete with ingredients like corn germ flour or oilseed proteins. It appears especially promising for dough-like batters for fastfood products intermediate to breads and cakes—pancakes, hamburger buns, and doughnuts, for example.

Home economist Kathleen A. Warner critiques Dr. Christianson's technique as he slices a loaf to show the uniform texture of baked goods made from xanthan-starch batters. The dough-like batters can be molded into a variety of loaf, bun, and roll shapes for fast food products (0975R1883–18).



***Above:** Ms. Warner holds two pans of batter that attest to the rising ability of xanthan starch batter. Batter on the right has just been placed in the baking pan; the unkneaded yet fully risen batter on left was placed in the pan just 60 minutes before and is ready for the oven (0975R1883–13). **Below:** The viscosity and stretchability of starch batter containing xanthan gum is amply demonstrated here (0975R1882–18).*



Xanthan gum is used in foods to affect physical properties such as pourability in salad dressings. Produced by a micro-organism *Xanthomonas campestris, growing* on glucose, also called corn sugar, the gum was discovered in earlier research at the Northern Regional Research Center.

In the dough studies, Dr. Christianson and Dr. Gardner used 1.2 to 2.4 parts by weight of xanthan for 100 parts of basic formula. Other ingredients included the starch, corn oil, dry milk solids, salt, sugar, yeast, and water.

The chemists replaced as much as a fourth of the starch in the basic formula with an equal weight of soy concentrate, 73.8 percent protein, or soy isolate, 95 percent protein, to make enriched doughs. They did not need dough strengtheners or improvers even for 22-percent protein foods.

Starch doughs without xanthan did not rise when baked. They remained flat, brittle, and coarse textured.

Doughs made of wheat starch and xanthan gum—even those with protein added—baked to resilient loaves with smooth, fluffy textures. Starch foam-loaves containing soy isolate and 2.4 percent of xanthan compared favorably in volume, lightness, and texture to breads baked from commercial flours.

Foam loaves containing 1.8 percent of xanthan had irregular sized gas cells and coarse texture. Loaves containing 1.2 percent of xanthan had even coarser textures and reduced volume.

Loaf volume fluctuated more and dropped more sharply with the addition of soy concentrate than it did with soy isolate.

"Gelatinized starch, xanthan, and soy isolate are largely hydrophilic ingredients," Dr. Christianson points out. "This ability to take up water may account for their compatibility in doughs. We expect continuing studies to show why starch is so free to take up water with xanthan and how this improves compatibility for a variety of dough and batter foods." □

Rx for sixweeks fescue

SIXWEEKS FESCUE—a troublesome winter annual grass that causes ranchers great financial loss—can now be controlled. ARS studies on this weedy grass got underway after ranchers on the shortgrass plains, an area that extends roughly from Montana to Texas and New Mexico, indicated that one of their greatest needs was control of sixweeks fescue.

Cattle can gain 100 pounds less during a summer when sixweeks fescue is abundant. At today's beef prices, that's about a $35 to $40 loss per head.

Because cattle dislike that plant so much, they will overgraze bottomland ranges rather than graze upland ranges where sixweeks fescue is abundant. Cattle carefully graze around sixweeks fescue plants and, if they accidentally include one in a bite, they drop the whole mouthful. If a range contains too much sixweeks fescue, the cattle will not even graze it to select out desirable blue grama grass.

The abundance of sixweeks fescue varies greatly from year to year. Above-average precipitation in the spring appears to promote its growth and seed production. If the fall also has above-average precipitation, conditions are ideal for seed germination and seedling emergence, creating thick stands the next year. Records at the Central Plains Experimental Range near Nunn, Colo., indicate that these conditions occur about 2 to 4 years out of every 10.

Walter R. Houston and Donald N. Hyder, range scientists at the Crops Research Laboratory, Ft. Collins, Colo., stated that herbicide may be applied only in the years that sixweeks fescue is a problem. They discovered that 1 pound per acre of either atrazine or simazine applied either in fall or spring effectively controlled the fescue. The herbicides may be applied in the fall if the stand of sixweeks fescue is thick or as late as in May.

Since cool-season grasses such as needle-and-thread and western wheatgrass are susceptible to these herbicides, the scientists in their experiments found anything above these rates was detrimental.

However, these herbicides have not been cleared by the Environmental Protection Agency for use in the shortgrass plains.

The scientists conducted the tests from 1970 through 1973 on sandy loam and fine sandy loam soils. The average annual precipitation is about 12 inches at Nunn, with about 9 inches occurring during the growing season of May through September. □

Lowering the mating rate

MATING RATES can be used to measure some effects of gamma radiation on codling moth reproduction capabilities.

Codling moth larvae are the most destructive pests of the Nation's apple crop. The larvae also infest pears, English walnuts, and other pome and stone fruits throughout the world. ARS is testing the use of laboratory-reared moths sterilized by exposure to gamma radiation as a means of controlling codling moth infestations in orchards.

In a recent study, male moths exposed to gamma radiation showed a lower mating rate than untreated males.

Female mating propensity remained unchanged when exposed to 0 to 15 kilorads of gamma radiation, but surpassed the mating rate of untreated females when treated with 20 to 40 kilorads.

Entomologist Robert B. Hutt, Yakima, Wash., ran more than 100 mating trials, using moths that had been treated with various dosages of gamma radiation and untreated moths. He then measured responses to irradiation on the basis of mating propensities.

Response varied with respect to the age of the moths, length of time of colonization, gamma ray dosage, dose rate, and sex.

Mating propensity of untreated male moths increased up to the third day of the mating period and then decreased. Irradiated males followed the same pattern but, with some exceptions, at a lower rate of mating. Length of colonization decreased the mating rate of both treated and untreated male moths. □

Self-pollinated single introductions of S–1 pearl millet seeds, packed in their own air-tight and moisture-proof containers, will provide germ plasm for a centennial year to come (0975X1921–21).

Storing seeds for a century

A plant geneticist wears many hats. In turn, he is explorer, farmer, sexologist, and antique collector *par excellence*. He explores and gathers new and old varieties, sows, harvests, and threshes, breeds and crossbreeds succeeding generations of plants and, finally, he can successfully preserve these seeds for posterity as germ plasm lines, pools, or mixtures.

In fact, if a breeder were to begin in 1975 to properly store pearl millet germ plasm, the hereditary material of the germ cells, scientists predict that his collection of this small-seeded cereal and forage grass would be viable for germination in the year 2075.

At Tifton, Ga., 70 percent of pearl millet seeds which were dried to less than 12 percent moisture, enclosed in air-tight containers, and stored at 5° C germinated after 26 years.

"Much of the success of any plant breeding program depends on the diversity of the available germ plasm," says research geneticist Glenn W. Burton at the Georgia Coastal Plain Experiment Station in Tifton. "Breeders and agencies have been developing 'world' germ plasm collections for many crops, but a highly cross-pollinated crop like pearl millet can be maintained only in storage or in an isolated field."

Attempts to maintain variable varieties by repeated selfing (self-pollination) or sibbing (pollination between family-related plants) in a nursery row invariably result in both loss of vigor and genes.

To help solve this problem, germ plasm pools are prepared by mixing together a number of introductions and then growing the mixture in isolation where its components can intermate naturally. After several generations the germ plasm becomes a useful reservoir of plants or of new lines for quantitative genetic studies, but genes are lost.

"We believe long-time storage either as first-generation inbred lines or mixtures of such lines is the only practical way to preserve pearl millet germ plasm without loss," says Dr. Burton. "Our studies indicate that growing several generations of a germ plasm pool of a cross-pollinated crop like pearl millet usually narrows the phenotypic variability of the original pool—visible traits like dwarfness or hairiness which help characterize a plant. The germ plasm pool loses genes and it also obscures characteristics that are hard to recover, like very long seed heads."

These disadvantages were apparent in a comparison of the first and the last generations of six different

Researchers harvest pearl millet seed heads covered to prevent cross-pollination. Some seeds will be stored

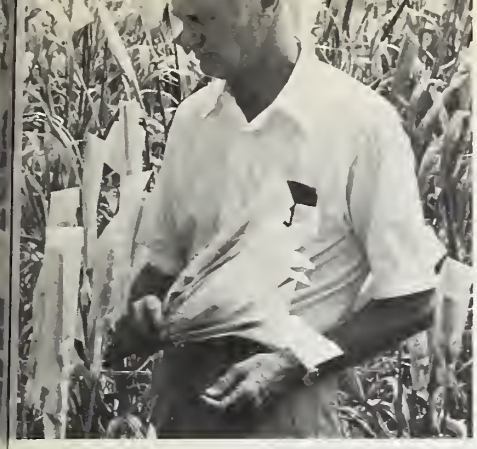
germ plasm pools of up to 85 percent cross-pollinated pearl millet, *Pennisetum americanum* (L.), which were grown in isolation three to five generations at Tifton.

Among many factors that can contribute to gene loss and gene shift are gene frequency, gene dominance, anthesis (flowering date), percentage of natural selfing, pollen movement, wind direction and velocity during flowering, size of the population grown, and seed yield.

From studies beginning in 1961 with a pool of equal quantities of seeds of 47 elite Tifton inbreds and 78 introductions, Dr. Burton concludes that growing germ plasm pools in an environment with short days and temperatures approaching 40° C will make most plants flower at about the same time. These conditions will also facilitate intermating and reduce gene loss.

Other methods to reduce gene loss are pooling fewer lines: selecting plants to advance the population as if they were self-pollinated; and, particularly important, preparing pools from equal numbers of live seeds from each selected plant.

"Because of the uncertainty of pollen movement, the plant breeder should select within a germ plasm pool females carrying desirable identifiable genes," said Dr. Burton. "In pool E, the fifth of our germ plasm pools at Tifton, dominant red and



while others will be used to increase another generation for breeding research (0975X1921–13).

purple genes could have been preserved in this way. The five recessive chlorophyll deficient genes—cd's—that were lost could not have been identified. Suppose that these five cd's had been genes for resistance to some new pest that will appear in the future. They would have been lost and future generations would have been poorer because of it."

The formula for 100-year-old millet seeds? From several ecotypes—types which survive as a distinct group through environmental selection and isolation—seeds are dried down to 5 to 7 percent moisture content in a forced-air oven at 40° C for 24 hours. They are then packed in many small, airtight, moisture-proof containers for easy distribution, sampling, and storage at more −18° C; providing germ plasm for breeders of food and forage for a centennial year to come. □

Gallon cans containing mixtures of equal quantities of S–1 pearl millet seeds from 430 introductions are kept in cold storage by Dr. Burton for release to plant breeders (0975X1919–34).

Dixie chicks eat more

WHICH consume more feed? Chickens or hogs?

According to figures compiled in a study of animal numbers and feed requirements projected to 1985, the South's poultry population will out-eat the hog family by 53 percent to the hog's 16 percent. This margin is based on a projected 53.5 million tons of feed concentrate, equivalent to corn in feeding value. Feed concentrates contain large amounts of energy in relation to bulk.

Except for dairy cows, 11 States below the Mason-Dixon Line have experienced faster growth in animal numbers than the rest of the United States.

By 1985, says ARS agricultural economist Yvonne Davies at the Russell Research Center, Athens, Ga., the South will have 3.5 billion broilers, 190 million layers, 288 million layer replacements—pullets up to 20 weeks old—and 70 million turkeys. There will be 20 million hogs, 4 million "fed" cattle, and 2 million dairy cattle.

Poultry, still the shopper's all-occasion favorite, will consume the most with 53 percent. Cattle fattened to provide beef ranging from U.S. Choice sirloins to ground chuck will rank second, consuming 26 percent of the South's total feed requirements. Hogs rank third with 16 percent of the feed. Grade A milk will come from dairy cattle which consume, comparatively, the least—a surprising 6 percent.

But in Arkansas alone, feed concentrate needs will be almost strictly for the birds—poultry feed requirements will account for 95 percent of the estimated 6.2 million tons required for the animal classes included in economist Davies' study. □

Too much pollutes

FERTILIZER nitrogen in excess of crop use can move below the root zone as a potential source of nitrate pollution of ground water. But the pollution potential may be minimal if nitrogen application is in balance with removal by crops.

Earlier laboratory and field studies strongly suggested the hazard of ground water pollution with excessive nitrogen fertilization. Iowa research now documents the hazard.

Nitrate-nitrogen in the soil profile below the root zone increased almost four-fold in 3 years with nitrogen applications at 2½ times the recommended rate for corn.

At the recommended rate, 150 instead of 400 pounds of nitrogen per acre, ARS scientists detected no increase in nitrate below the root zone.

The scientists made the comparisons near Treynor, Iowa, on adjacent watersheds contour-planted to corn. They took sets of continuous soil cores to 20-foot depth at least annually on both watersheds to monitor changes in soil nitrate levels to ground water.

At the high fertilization rate, 641 pounds of nitrate-nitrogen per acre moved below the root zone during the study. The third year, an increase from 3.7 to 12.9 parts per million nitrate concentration in the soil near the water table indicated that fertilizer nitrogen was reaching the saturated soil zone that serves as ground water and moves laterally as surface flow.

ARS soil scientists Gerald E. Shuman and microbiologist Thomas M. McCalla at Lincoln, Nebr., hydraulic engineer Keith E. Saxton at Columbia, Mo., and technician Howard T. Knox at Council Bluffs, Iowa, conducted the study in cooperation with the Nebraska and Iowa Agricultural Experiment Stations. □

Mr. Puttler uses an aspirator to collect the beneficial parasite Campoletis sonorensis*—a parasite that attacks the soybean podworm. The biology and behavior of this parasite is being studied to increase its potential usefulness as a biological control agent (0975X1779–31).*

Researchers use several methods to determine insect populations in test fields. The aim of the research is to predict the level of parasitism, at any stage of soybean growth, at least 1 week before the attack occurs naturally. These predictions are based on trapping records. Mr. Schmidt collects a sample from a rotary trap, only one of the trapping techniques used (0975X1780–25A).

The naturally occurring fungus Nomuraea rileyi *attacks several different species of larval soybean pests. The soybean podworm, green clover worm, cabbage looper, and soybean looper are equally susceptible to this fungus, as is evidenced by these dead larvae (0975X1787–20).*

Defending soybeans, naturally

A TEAM of scientists is directing its research toward preventing a potential problem: greatly reduced soybean yields due to attack by insects. They're exploring the intricacies of nature to learn how they can work with it.

The studies encompass a host of insect pests' natural enemies such as parasites, predators, and pathogens. "By developing and managing the effects of these biological control agents, we hope to relieve farmers of complete dependence on chemical insecticides that are toxic, harmful to the environment, and even ineffective as insecticide-resistant races of insects develop," says entomologist Carlo M. Ignoffo, leader of the Biological Control of Insects Research Unit, Columbia, Mo.

Scientists have completed 3 years of field studies and are now putting their findings together in a program to develop a management system for controlling soybean insects. They are designing the program for ready adaption to soybean ecosystems wherever and whenever insect infestations may develop.

Presently, in Missouri and much of the Midwest where agricultural pesticides are used with moderation, naturally occurring parasites, predators, and insect diseases usually hold soybean pests in check, says Dr. Ignoffo.

Defoliating and Losses. Soybean growers often could be spared expenses if they knew how much damage it took to reduce soybean yields to the level that equals the cost of applying insecticides. In studies to arrive at this economic threshold, entomologist Gustave D. Thomas found that leaf-chewing caterpillars such as green cloverforms, velvetbean caterpillars, and loopers can defoliate soybeans by as much as 40 percent early in the season without decreasing yields by even ½ bushel per acre. If this level of defoliation occurs later, when pods are beginning to fill, yields may decline by more than 15 percent.

The soybean podworm, also known as corn earworm and cotton bollworm, chews on the soybean pods. Entomologist K. Duane Biever found these pests can damage 10 percent of the developing pods without reducing yields because the undamaged beans grow to larger-than-normal size. He estimated that 40,000 podworms per acre (about 3 worms per foot of row) will reduce yields by less than 2 percent.

Dr. Biever also is looking to insect growth regulators (IGR) as another means to control podworms and other soybean pests. He and his coworkers applied an experimental IGR to caged plots of soybeans to inhibit development of soybean podworms. Pod damage in the treated plots was 65 percent less than damage in control plots.

Integrating Pest Controls. Entomologist Norman L. Marston treated a field with ethyl parathion to evaluate the effect of insecticide applications on pests and beneficial insects. It greatly reduced populations of parasites and predators for several weeks, allowing numbers of defoliating caterpillars to increase by three-fold above those in untreated fields nearby.

Other chemicals, such as the herbicide 2,4–DB, may be relatively harmless to beneficial insects in the soybean ecosystem. In laboratory studies with this herbicide and other chemical and biological insecticides, entomologist Jack D. Wilkinson and his colleagues found malathion, carbaryl, and toxaphene can be useful in integrated control programs. The insecticides, applied in less than currently recommended field dosages, could curb rapidly increasing populations of certain insects without eliminating their natural enemies.

Microbial insecticides may also play an important role in pest control. The research team observed low mortality among beneficial insects that had been exposed to the *Heliothis* nuclear polyhedrosis virus (NPV) or

Dr. Ignoffo examines soybeans defoliated by the soybean podworm. The same insect is also destructive to cotton and corn. ARS entomologists are evaluating the effectiveness of the virus Heliothis nuclear polyhedrosis *against the soybean pod worm. It is the first virus to be commercially registered as a biological control agent against the pest (0975X1784–16).*

Scientists are evaluating the effectiveness of the beneficial predator Podisus—*here attacking a cabbage looper larva.* Podisus *also attacks the soybean podworm, the* green *clover worm, and the soybean looper (0975X 1785–16).*

the bacterium, *Bacillus thuringiensis* (BT).

Using Living Insecticides. In the 1960's Dr. Ignoffo's research with ARS and industry brought about technology for mass producing the *Heliothis* virus. This first viral insecticide was proven safe for field use in cotton and may become available to farmers in 1976. In initial field-cage studies, this same virus has effectively controlled *Heliothis* insects attacking soybeans.

BT is currently registered for control of cabbage loopers and several other pests of vegetable and row crops and is effective in various degrees against most of the caterpillars that attack soybeans.

Applying either BT or *Heliothis* NPV with conventional spray equipment, entomologist Donald L. Hostetter and agricultural engineer David B. Smith demonstrated that microbial insecticides are not affected adversely as the spray passes through tank agitators or nozzles.

"We're currently seeking ways to disperse these living insecticides thoroughly, quickly, and uniformly and to do this we may have to design new equipment," says Dr. Smith. The researchers are studying new formulations of microbial insecticides that include feeding stimulants, sunlight protectants, and humectants and are determining what effects these have on coverage.

Combating Green Cloverworms. Another microbial organism that one day may be used as an insecticide is the fungus *Normuraea rileyi.* In nature, this fungus plays an important role in reducing populations of green cloverworms, but generally it develops too late to prevent reductions in soybean yields. Scientists are evaluating this fungus for applications as a microbial insecticide or as a preventive measure that could be used each year before the insect problem develops.

The fungus also gets considerable help from parasites. Entomologist Benjamin Puttler has discovered that at least a dozen species suppress the green cloverworm in soybeans before the crop is in its critical growth stages. "We hope to build into our program, methods to predict numbers of caterpillar pests and abundance of their natural enemies at least 1 week before any soybean growth stage," says Mr. Puttler.

Predators also exact major tolls on green cloverworms. Three predators discovered in Missouri soybeans account for more than 90 percent of the total predation, says Dr. Marston. He is assessing possible uses of attractants

and food supplements to increase populations of beneficial insects in soybean fields.

Feeding the Systems. Most of the studies that the researchers conduct are dependent on laboratory-reared insects. Field studies often require enormous numbers of insects, notes Dr. Ignoffo. To meet these needs, eight species of soybean pests are kept in culture continually.

Entomologist Willard A. Dickerson manages the insect-rearing facility and conducts research on nutritional needs of harmful insects. These studies may prove helpful in a search that is underway for new insect-resistant strains of soybeans.

For some studies, harmful insects and their parasites must be reared concurrently. Entomolgist J. David Hoffman and his colleagues are developing a more efficient procedure for rearing tiny parasitic *Trichogramma* wasps which in nature deposit their own eggs into eggs of soybean pests.

An acceptable substitute for host eggs could reduce rearing costs enough to permit widespread use of the beneficial insect.

Improving Parasites' Environment. In other studies, entomologist Gerald T. Schmidt is studying the effects of light, odor, and other factors upon the behavior of insect parasites such as the *Campoletis sonorensis*, which attacks soybean podworms. This research, hopefully, will help increase the parasite's effectiveness.

With scientists of many disciplines who work outside the laboratory, the entomological research team is evaluating effects of agronomic practices on beneficial and pest insects in soybeans. This research is conducted on a 100-acre farm with conventional farm equipment. The plots in the joint ARS-University of Missouri project are managed with variations in planting dates, tillage, herbicide treatments, row spacings, and crop rotations.

Through numerous field experiments, the ARS scientists have demonstrated that natural agents effectively suppress insect pests in the balanced Missouri soybean ecosystem—even though these pests are present every year. If damaging insect populations do develop, hopefully the researchers will have already learned how to predict the problem and will have developed selective control measures.

"We want to develop controls that are compatible with beneficial insects and diseases and that don't hamper progress of future agricultural technology," says Dr. Ignoffo. "If we judiciously select our insect control agents and use them properly, we may never experience the problems that have developed in other crop ecosystems." □

***Top:** Researchers infest a test soybean field with insect larvae to evaluate the effectiveness of a naturally-occurring fungus,* Nomuraea rileyi *(0975X1784–29). **Left:** To relate yield loss to defoliation by insects, the total leaf surface must be known. Until recently, this required painstaking, mathematical computations. Now, the newly-developed "leaf meter" makes these determinations. Dr. Thomas feeds in a leaf as one just metered drops out of the apparatus' rear (0975X1777–11).*

Mrs. Jackson, of the Plant Physiology Institute, Beltsville, Md., employs flameless atomic absorption—one of the techniques that Yugoslav scientists have improved for the accurate measurement of mercury. The technique holds promise for tracing the movement of mercury in the biosphere (0875X1196–21A).

Tracing mercury in a biosphere

It is one task to sample Lake Erie for mercury and quite another to analyze the biosphere in a 300-square-mile area where mercury has been mined and processed for nearly five centuries.

This has been achieved by Yugoslav scientists at Idrija, one of Europe's important mercury mining areas. A few earlier investigations of the distribution and uptake of mercury (Hg) had been prompted by the outbreak of methyl mercury (MeHg) poisoning in Japan in the fifties and sixties. Scandinavian scientists had studied the environmental consequences of mercury-containing pesticides and of industrial discharges from chloralkali and paper industries. The belated discovery of relatively high levels of mercury contamination in North America in 1970 heightened concern to know more about the biological impact of this element, which has versatile uses in agriculture, industry, transportation, and research.

Chemist Patricia C. Jackson, ARS-cooperating scientist, says, "The extreme toxicity of methyl mercury compared to inorganic mercury and the capacity of some organisms to convert inorganic mercury to methyl mercury is a principal reason why this work was undertaken.

"Idrija, in the Slovenian Republic, provided a unique opportunity to study the cycle of mercury and its effect on life forms because of the long history of mercury discharge, the nature of the environment, the low population mobility, and the reliance on local food supplies."

The project's value, Mrs. Jackson adds, is particularly enhanced by the improved techniques the Yugoslavs developed for accurate measurement of total Hg by neutron activation analysis and flameless atomic absorption. Another very significant contribution was the development of a new, simple, precise method of MeHg analysis of biological tissue. The new method is a considerable improvement over previous methods and will have worldwide application in view of the toxicity of MeHg and its wide occurrence in fish and animals consumed by man.

The Yugoslav samplings included air, soil, water, and tissues from humans, fish, and plants. Mrs. Jackson reports that this work appears to be the first observation of MeHg in plants. This indicates another dimension to the concentration of Hg in the food chain.

Results of the Yugoslav studies show that Hg levels of most plants were variable, but quite low—1 to 50 parts per billion (ppb) compared to the Hg content of soils in which

they grew—100 to 600 thousand ppb. Carrots, grasses, and some weeds were found to have more Hg generally than other plants—as much as 800 ppb fresh weight.

Broadleaf plants exposed to high levels of aerial Hg contained more Hg than narrow-leaved plants. Certain species of mushroom contained more Hg than vascular plants and more than the soil in which they grew. Moreover, some of the Hg in mushrooms was in the form of MeHg, which was not found in vascular plants.

The Hg level was high in fish and amphibians, most of it occurring in the methyl form. Hg levels in the fast flowing Idrijca River were negligible (0.1 to 0.3 ppb) except for waste water from Hg processing (15–4,700 ppb). For comparison, the U.S. Public Health standard of maximum level for drinking water is 5 ppb.

Air samples ranged from 2.5 nanograms (ng) per cubic meter (m^3) in a residential area 23 miles from Idrija to 579 ng/m^3 in the town center of Idrija. A nanogram is one billionth of a gram. A cubic meter is 1.308 cubic yards.

Studies of Hg distribution in people exposed to high Hg levels revealed very high concentrations in thyroid and pituitary glands and in brain, liver, and kidney. Mrs. Jackson says, "The high levels of mercury found in the thyroid and pituitary glands are new findings insofar as I am aware. Also, appreciable portions of the mercury in humans—10 to 80 percent—occurred in the form of methyl mercury, an important finding in view of the fact these people were exposed to inorganic mercury. These findings could bear on the nature of toxicological effects of mercury."

This project was conducted under the provisions of Public Law 480 and was directed by Dr. Lado Kosta, Institute of Jozef Stefan, Ljubljana, Yugoslavia. □

When soil water matters...

Snow is often regarded as a nuisance. It can make travel difficult and often dangerous and is hard on livestock. Melting snow can cause flooding and soil erosion.

But snow has its good points. It is a valuable resource for Great Plains agriculture. Improved management can make it even more valuable.

ARS scientists have proved that level benches constructed on hillsides can hold and store water from both snow melt and torrential rains for crop production. Level benches have much wider channels than conventional terraces to provide more uniform distribution of collected water. These benches are nearly level in all directions, and are diked at their ends and downhill sides to hold more water.

In ARS studies in northeastern Wyoming, level benches absorbed about three times more water in the top 6 feet of soil during the winter than did surrounding areas. During two winters, the average yearly soil water increased about 6 inches each on 13- and 27-foot wide benches compared to about 2 inches on the natural terrain, which benefited less from the snow melt.

The extra water increased forage production on the level benches. Four years of testing have shown that 13-foot wide benches produced, on a yearly average, 13 percent more forage than conventional land areas. The 27-foot wide benches produced 15 percent more.

Soil scientist Frank Rauzi, says, "We purposely constructed the benches so they would be exposed parallel to the prevailing winds. Our studies have shown that even this way snow is trapped and provides more moisture for forage. If they are placed perpendicular to prevailing winds, even more moisture would be trapped."

The 27-foot-wide benches were constructed on lower slopes with gradients of 1 to 6 percent, while the 13-foot-wide benches were on the steeper slopes with gradients of 6 to 15 percent.

For comparison, duplicate benches and check areas of natural terrain were each planted with Ladak alfalfa, Nordan crested wheatgrass, intermediate wheatgrass, a mixture of Ladak alfalfa and Nordan crested wheatgrass, and Ladak alfalfa plus intermediate wheatgrass. Alfalfa and intermediate wheatgrass were planted on the dikes as a vegetative barrier to trap more snow.

Mr. Rauzi applied 120 pounds of phosphorous per acre before seeding in May 1970. In addition, all benches and check areas except those seeded to only alfalfa received 80 pounds of nitrogen (N) per acre in May 1971. In April 1974, he applied an additional 40 pounds of N per acre.

Both grass-alfalfa mixtures produced good overall yields, indicating that they are compatible. Because wheatgrass is shallow rooted, it uses water from only the top 1 to 2 feet of soil. Since alfalfa has a tap root, it makes use of deeper soil water.

The studies also showed that neither crested nor intermediate wheatgrass grown alone on the benches benefited from the extra water in the soil.

If the benches—which are essentially permanent and readily amortized—are to be grazed, cattle should be kept off the first 2 or 3 years to prevent damaging the newly constructed dikes. Growing small grain on the benches the first year would provide organic matter and a better seedbed for subsequent alfalfa seedlings.

These studies were conducted in cooperation with the Wyoming Agricultural Experiment Station, Gillette, and USDA's Soil Conservation Service. □

1975 INDEX

When reporting research involving pesticides, this magazine does not imply that pesticide uses discussed have been registered. Registration is necessary before recommendation. Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if not handled or applied properly. Use all pesticides selectively and carefully.

PROTECT
Use Pesticides Safely
FOLLOW THE LABEL